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INTENSIFICATION OF THE EXTRACTION PROCESS IN TECHNOLOGIES FOR OBTAINING FUNCTIONAL PRODUCTS

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Abstract. *The article presents a solution to the issue of intensification of the process of extraction of biologically active substances (BAS) from field crops using the example of flax seeds and soybeans. An analysis of modern promising methods of BAR extraction from plant raw materials, advantages and disadvantages of devices for the implementation of methods of influence on raw materials was made. In order to determine the optimal effect of the mechanisms of the DPEI method, it is proposed to carry out the extraction process in parallel in pulsating dispersers of the impact and cavitation type, developed at the IET of the National Academy of Sciences of Ukraine. As a result of experimental studies, it was established that the cavitation mechanism is the most energy-efficient and rational way of influencing the processing of field crops. For whole and ground flax seeds, soybean extrude, the indicators of the amount of dry matter yield after extraction in a cavitation-type disperser are higher than in an impact-type disperser by 2%; 7,5%; 5,8%. in accordance. In all mixtures, the non-Newtonian character of viscosity is more clearly manifested with an increase in the duration of processing, which does not exceed 10 min. The results of the conducted research can be used in technologies for obtaining functional products with maximum preservation of thermolabile bioactive components.*

Key words: *the method of discrete-pulse energy input, cavitation, pulsation apparatus, disperser, extraction, flax seeds.*

Introduction.

The main task of the process of extracting plant raw materials is to study changes in its physic-chemical and structural-mechanical properties during

processing [1, 2], because this significantly affects all stages of the further technological process of obtaining functional products [3]. The technology of processing field crops for functional products requires maximum preservation of bioactive components [4], which can ensure extraction at low temperatures. Before carrying out the process of extracting BAS from the seeds, preliminary soaking is required, the duration of which depends on the speed of air displacement from the cell. Using ultrasonic devices [5], which provide a sound-capillary effect, not only the acceleration of the displacement of air bubbles is achieved, but also the conditions for its dissolution in water are created. Under the influence of ultrasonic vibrations in the processed environment, there is an active influence on the cellular and intercellular space of the seed material, which ensures a faster transition of bioactive components from the cell to the extracting and leads to the intensification of the extraction process [1, 5]. Simultaneously with the extraction, the process of dispersion in the created acoustic environment takes place. Optimizing the process of dispersing seed raw materials is of great importance for the intensification of the extraction process [4]. The cavitation mechanism is a decisive factor in the acceleration of mass transfer processes occurring under the influence of an acoustic field [6].

In recent years, methods of intensification of extraction processes are associated with the use of ultrasonic, hydrodynamic, and electric discharge devices, which implement the effects of cavitation, which allows influencing the rate of internal mass transfer in the cellular structure [6, 7]. Ultrasonic and electric pulse extraction methods are practically not used in industrial production due to relatively low productivity and high energy costs. When using such hydrodynamic cavitators as rotary-pulsation apparatus, centrifugal pumps, Venturi tubes and others in extraction technologies, the structural-mechanical and abrasive properties of raw materials should be taken into account [2, 3]. Hydrodynamic devices also include pulsating devices with an active diaphragm [8 – 12], created at the Institute of Engineering Thermophysics of the National Academy of Science of Ukraine on the basis of the principle of discrete-pulse energy input (DPEI), which are used in production as effective homogenizers, dispersers, and extractors.

The purpose of the presented work is to study the regularities of the influence of a set of DPEI mechanisms on the physic-chemical and structural-mechanical properties of field crops during processing in pulsation apparatus.

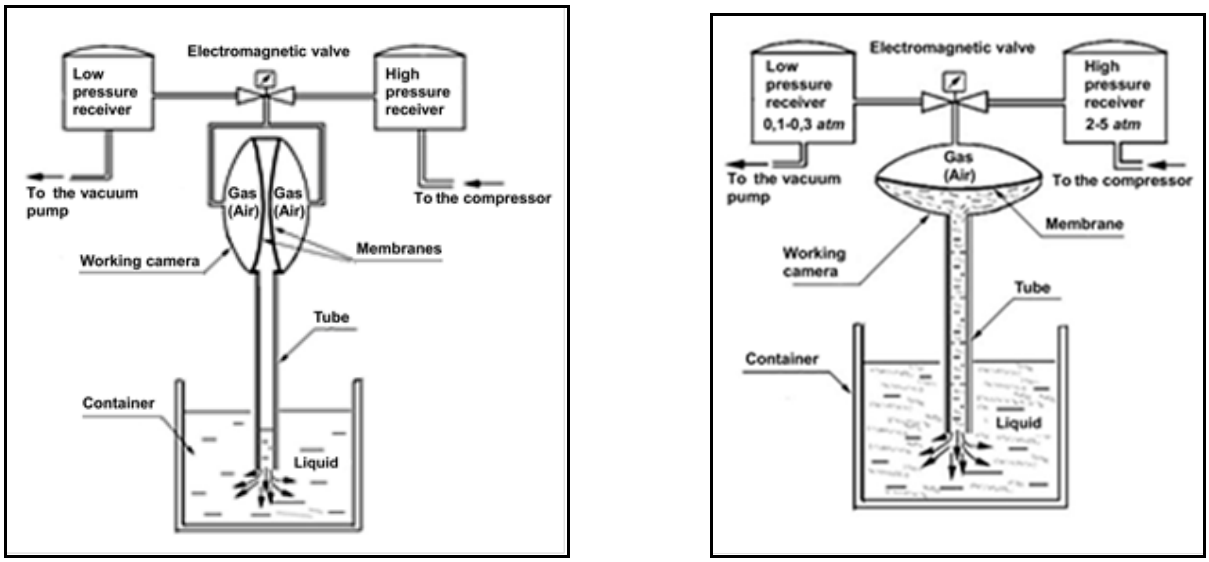
The tasks of the research are to carry out the process of dispersion in the impact and cavitation pulsation devices, to determine the parameters of the physic-chemical and structural-mechanical properties of the obtained extracts, to determine the rheological parameters of the obtained mixtures, to investigate the microstructure of the obtained samples by optical microscopy.

Main text.

Initiation of the cavitation mechanism during extract processing in a cavitation reactor leads to a significant acceleration of the process at its slowest stage, that is, it allows influencing the internal diffusion coefficient.

The schematic diagram of the impact type pulsating disperser is presented in Figure 1a. The principle of operation and operating parameters are described [8, 9, 12]. The schematic diagram of the cavitation type pulsating disperser is presented in

Figure 1b. The principle of operation and operating parameters are described [10, 11]. For objects of research: whole and ground flax seeds, soybean extrude, separate soybean extrude with whole flax seeds (to determine the effect on structural and mechanical properties after processing). The flax was ground in a manual grain mill with steel millstones. Using the method of preliminary laboratory studies [4, 5, 10], the hydro modulus of 1:7 was determined, and the temperature of the extracting equal to 30 °C, which was maintained during the study, was also determined. Water was used as an extracting.

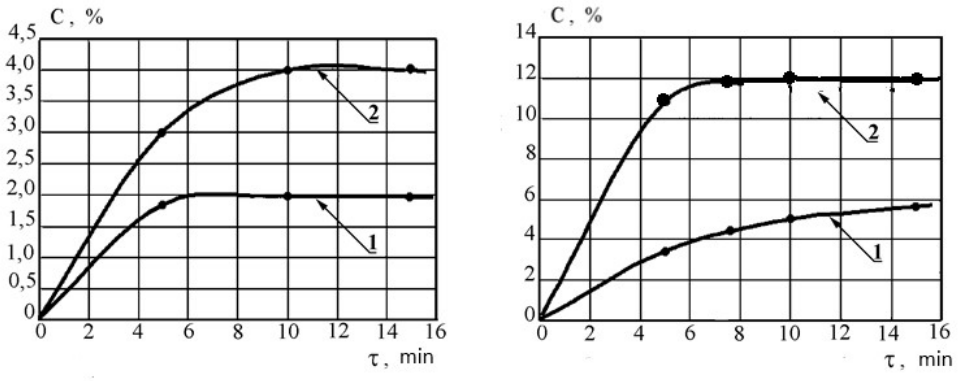


a) b)

Figure 1 – Schematic diagram of the impact type pulsating disperser (a) and the cavitation type pulsating disperser (b)

After extraction, the obtained samples were experimentally determined: the content of dry substances according to the State Standard of Ukraine (DSTU) 7804:2015, the amount of protein according to the nephelometric method, the rheological indicators of the extract using a rotary viscometer "Rheotest-2". The microstructure of the samples was studied using a Carl Zeiss Axio Imager Z1m light microscope.

In the course of experimental studies of the process of extracting whole flax seeds without pre-soaking, as well as ground flax and soybean extrude with whole flax seeds in a cavitation-type pulsating disperser, cloudy suspensions of light gray color were obtained. The results of the study of the microstructure of the obtained mixture samples showed the predominant presence of particles smaller than 5 μm in size. Round objects with a size of 2 μm are observed around whole flax seeds in aqueous suspension. The integrity of the seed during processing in pulsating dispersers was not violated, the structure did not break. The results of the yield of dry substances depending on the duration of processing from whole and ground raw materials on the example of flax are presented in Figure 2. It was found that for each type of seed, the extraction process takes place more intensively in a cavitation-type disperser, as opposed to an impact one. For soybean extrude and ground flax, the difference in the indicators of the amount of dry matter output, comparing after processing in the devices, is about 5,8 % and 7,5 %, respectively.

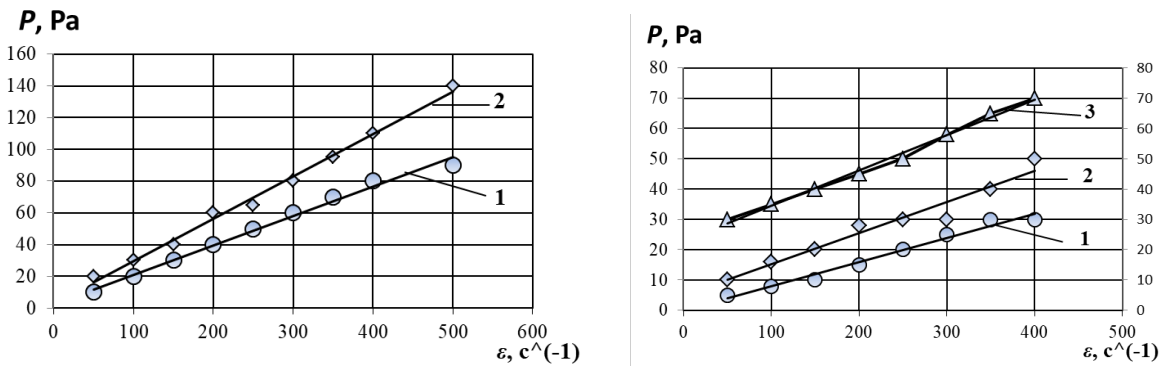


a) b)

Figure 2 – The amount of dry matter output C, % depending on the duration τ, min of processing in pulsation devices: 1 – impact type; 2 – cavitation type for whole (a) and ground (b) flax seeds

For whole flax seeds, the difference is 2 %. The difference between the protein yield of ground flaxseed and whole in these devices is 1,8 % and 2 %, respectively. The yield of protein also depends on the duration of processing. In general, 10 minutes of processing in pulsating dispersers is enough for both whole and ground flax seeds.

Experimental studies related to the study of physic-chemical, biological and mechanical processes provide an opportunity to optimize the organization of objective quality control of finished products. The food industry is connected with the processing processes of structured dispersed systems, which are characterized by such mechanical and rheological properties as viscosity, elasticity, creep, plasticity, strength, relaxation, etc. The viscosity curves of the obtained samples after processing under the influence of the cavitation mechanism in the cavitation-type pulsating disperser are shown in Figure 3. Experimental data on the dependence of the shear stress P on the shear rate $\varepsilon = \Delta v/\Delta r$, obtained on a rotary viscometer «Rheotest-2» for two samples of the treated mixture. Conducted rheological studies showed that all mixtures after extraction have the properties of a non-Newtonian liquid.



a) b)

Figure 3 – Rheological properties of the resulting mixtures after cavitation treatment: a – whole flax seeds, b – soybean extrudate with whole flax seeds. Processing time, min: 1 – 5; 2 – 10; 3 – 15

The extract of whole flax, as can be seen from Figure 3a, has the characteristic properties of a pseudo-plastic liquid, when the effective viscosity η=dP/dε decreases with increasing shear rate. The same rheological character is observed in the processed mixture of ground flax. Mixtures of soybean extrude with whole flax seeds have fundamentally different rheological properties. The data in Figure 3b indicate that this product has the typical character of a Bingham viscoelastic liquid at which the values of the ultimate stress increase with processing time: For all the mixtures studied in the work, the non-Newtonian nature of the viscosity is more clearly manifested when the processing time in a pulsating cavitation type disperser increases.

Summary and conclusions.

Were received maximum possible yield of biologically active components from the experimental raw materials was obtained under the influence of cavitation effects. For whole flax seeds, the yield of dry matter is 4 % when processed in a cavitation type disperser, obtained within 10 minutes. 6% (2 times) more yield of dry matter was achieved from ground flaxseed by cavitation treatment in 10 min compared to treatment in an impact disperser. The maximum value of this indicator for a mixture of soybean extrude with whole flax seeds during cavitation treatment is 14%, which is 2,3 times higher than the value for pulsating impact. The protein content in the obtained suspensions was maximally extracted during 5 min of treatment in pulsating dispersers. Depending on the further application in the technological process, rheological dependence on the duration of processing should be taken into account.

Experimental studies of the comparative effect of a set of DPEI mechanisms on raw materials show the effectiveness of the application of cavitation during processing in a pulsating disperser without damage to the fiber structure. To obtain liquid suspensions with a maximum yield of protein, 10 minutes of processing is sufficient when applying the DPEI method in pulsation devices. The study of the extraction process was carried out at a temperature of 30 °C, which satisfies the peculiarity of the release of thermolabile BAS from raw materials.

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